CLAIMS

1. (original) A receiver for a received signal having two or more data levels, the received signal having been transmitted over a transmission channel, the receiver comprising:

(a) two or more channel estimators, at least one channel estimator for each different data level for the received signal, each channel estimator being configured to model the transmission channel to generate an estimated signal corresponding to one of the data levels; and

(b) a comparator configured to (1) receive the received signal and the estimated signal from each channel estimator and (2) select an output data level for the received signal.

2. (original) The receiver of claim 1, wherein each channel estimator implements a 2^{nd} order or higher model of the transmission channel.

3. (original) The receiver of claim 2, wherein the model is an adaptive model of the transmission channel that is dynamically controlled based on an error signal generated by the comparator.

4. (original) The receiver of claim 2, wherein each channel estimator comprises a processing path for each order term in the model of the transmission channel.

5. (original) The receiver of claim 4, wherein at least one of the processing paths in each channel estimator comprises a multiplication node having an adaptive coefficient that is dynamically controlled based on an error signal generated by the comparator.

6. (original) The receiver of claim 5, wherein a processing path in each channel estimator corresponding to a 1^{st} order term of the model with a coefficient having a value of 1, wherein the 1^{st} order term processing path is implemented without a multiplication node.

7. (previously presented) The receiver of claim 1, further comprising one or more adaptive equalizers, each adaptive equalizer configured to receive an ideal data level signal corresponding to one of the data levels and to generate an input signal for one or more of the channel estimators.

8. (original) The receiver of claim 7, wherein at least one adaptive equalizer is shared by two or more of the channel estimators.

9. (original) The receiver of claim 8, wherein all of the channel estimators share a single adaptive equalizer.

10. (original) The receiver of claim 7, wherein each adaptive equalizer is further configured to receive one or more future data levels and the receiver comprises a channel estimator for each different combination of current and future data levels.

11. (currently amended) The receiver of claim 7, wherein tap data for each adaptive equalizer corresponds to sliced symbols corresponding to [[the]] two or more of the data levels.

12. (original) The receiver of claim 1, wherein the comparator comprises:

(a) a subtraction node for each channel estimator configured to generate a difference signal between the received signal and the corresponding estimated signal; and

(b) a compare-and-select module configured to receive the difference signals from the subtraction nodes and to select the output data level for the received signal based on a difference signal having a smallest absolute value.

13. (original) The receiver of claim 1, wherein:

the transmission channel is an optical transmission channel; and

the two or more channel estimators and the comparator are implemented in a single integrated circuit as analog circuitry.

14. (original) A method for processing a received signal having two or more data levels, the received signal having been transmitted over a transmission channel, the method comprising the steps of:

(a) generating at least one estimated signal for each data level based on a model of the transmission channel; and

(b) processing the received signal and the estimated signal for each data level to select an output data level for the received signal.

15. (original) The method of claim 14, wherein step (a) comprises the step of implementing a 2^{nd} order or higher model of the transmission channel.

16. (original) The method of claim 15, wherein the model is an adaptive model of the transmission channel that is dynamically controlled based on an error signal generated during step (b).

17. (original) The method of claim 14, further comprising the steps of:

(c) generating a difference signal between the received signal and the corresponding estimated signal; and

(d) selecting the output data level for the received signal based on a difference signal having a smallest absolute value.

18. (previously presented) The receiver of claim 2, wherein the model of the transmission channel includes at least one of a 0^{th} order term and a 1^{st} order term.

19. (previously presented) The receiver of claim 18, wherein each channel estimator comprises a processing path for each order term in the model of the transmission channel.

20. (previously presented) The receiver of claim 7, wherein each channel estimator receives a different input signal from the one or more adaptive equalizers.

21. (previously presented) A receiver for a received signal having two or more data levels, the received signal having been transmitted over a transmission channel, the receiver comprising:

(a) an adaptive equalizer, a corresponding channel estimator, and a corresponding subtraction node for each data level; and

(b) a compare-and-select module, wherein:

each adaptive equalizer is configured to receive an ideal data level signal for the corresponding data level and to generate an input signal for the corresponding channel estimator;

each channel estimator is configured to model the transmission channel to generate an estimated signal corresponding to said each data level, each channel estimator implementing a 2^{nd} order or higher model of the transmission channel, wherein:

the model has at least a 0^{th} order term, a 1^{st} order term, and a 2^{nd} order term; and

said each channel estimator comprises a processing path for each order term in the model;

each subtraction node is configured to generate a difference signal between the received signal and the corresponding estimated signal; and

the compare-and-select module configured to receive the difference signals from the subtraction nodes and to select the output data level for the received signal based on a difference signal having a smallest absolute value.

22. (currently amended) A receiver for a received signal having two or more data levels, the received signal having been transmitted over a transmission channel, the receiver comprising:

(a) an adaptive equalizer;

(b) a set of ideal-data-level circuitry, a corresponding channel estimator, and a corresponding subtraction node for each data level; and

~~(b)~~ (c) a compare-and-select module, wherein:

the adaptive equalizer is configured to generate a single adapted equalizer signal for each set of ideal-data-level circuitry;

each set of ideal-data-level circuitry is configured to receive an ideal signal data level for the corresponding data level and to generate an input signal for the corresponding channel estimator;

each channel estimator is configured to model the transmission channel to generate an estimated signal corresponding to said each data level, each channel estimator implementing a 2^{nd} order or higher model of the transmission channel, wherein:

the model has at least a 0^{th} order term, a 1^{st} order term, and a 2^{nd} order term; and

said each channel estimator comprises a processing path for each order term in the model;

each subtraction node is configured to generate a difference signal between the received signal and the corresponding estimated signal; and

the compare-and-select module configured to receive the difference signals from the subtraction nodes and to select the output data level for the received signal based on a difference signal having a smallest absolute value.

REMARKS/ARGUMENTS

Claims 1-22 are pending in the application. Claims 11 and 22 are amended herein. Claim 22 has been amended to correct an inadvertent typographical error. The Applicant hereby requests further examination and reconsideration of the application in view of the foregoing amendments and these remarks.

Restriction Requirement

In paragraph 1 of the office action, the Examiner stated that "claims 1-20 are directed to species of configuration in Fig. 2" and that "claims 21 and 22 are directed to species of configuration in Fig. 3." The Examiner stated further that "no claims are generic" and required the Applicant to elect a single disclosed species for prosecution. As a result, in paragraph 3, the Examiner withdrew claims 21-22 from further consideration. The Applicant traverses this restriction requirement.

First of all, claims 1-7 and 10-20 are all directed to the configurations of both Figs. 2 and 3. For example, claim 1 recites two or more channel estimators and a comparator. Referring to Fig. 2:

- o Elements 205, 207, 209, 211, and 213 of Fig. 2 form an example of one of the "two or more channel estimators" of claim 1;
- o Elements 206, 208, 210, 212, and 214 of Fig. 2 form an example of another one of the "two or more channel estimators" of claim 1; and
- o Elements 215, 216, and 217 of Fig. 2 form an example of the "comparator" of claim 1.

Thus, claim 1 is directed to the configuration of Fig. 2. Referring to Fig. 3:

- o Elements 205, 207, 209, 211, and 213 of Fig. 3 form an example of one of the "two or more channel estimators" of claim 1;
- o Elements 206, 208, 210, 212, and 214 of Fig. 3 form an example of another one of the "two or more channel estimators" of claim 1; and
- o Elements 215, 216, and 217 of Fig. 3 form an example of the "comparator" of claim 1.

Thus, claim 1 is also directed to the configuration of Fig. 3. Analogous statements can be made about claims 2-7 and 10-20. As such, claims 1-7 and 10-20 are all generic claims. Moreover, the Examiner indicated that generic claims 3, 5-7, 10-12, and 16-20 are all directed to allowable subject matter.

In view of the foregoing, the Applicant submits that the restriction requirement is improper and that claims 21-22 should not have been withdrawn from further consideration. As such, the Applicant repeats the previous election of claim 1-20 with traverse.

35 U.S.C. 112, First Paragraph

In paragraph 5, the Examiner rejected claims 1-13 and 18-20 under 35 U.S.C. 112,first paragraph, as failing to comply with the written description requirement. In particular, referring to claim 1, the Examiner stated that the specification does not disclose "a comparator configured to receive the received signal and the estimated signal from each channel estimator." This is the second time that the Examiner has made this rejection and the second time that the Applicant has responded to this rejection.

Apparently, the Examiner is interpreting the comparator of claim 1 as covering only compare-and-select module 217 of Fig. 2. However, as explained in response to the previous office action, the

comparator of claim 1 covers **not just** compare-and-select module 217 of Fig. 2, **but also** subtraction nodes 215 and 216 of Fig. 2.

Support for this interpretation finds explicit support in original claim 12, which depends directly from claim 1 and which recites that the comparator of claim 1 comprises "a subtraction node for each channel estimator" and "a compare-and-select module." Thus, the comparator of claim 1 covers compare-and-select module 217 **and** subtraction nodes 215 and 216 of Fig. 2.

With this interpretation of the comparator of claim 1, the comparator does in fact receive the received signal (e.g., v_{in} in Fig. 2) and the estimated signal from each channel estimator (e.g., signals from elements 213 and 214 in Fig. 2).

For all these reasons, the Applicant submits that the rejections of the claims based on Section 112, first paragraph, have been overcome.

Claim Objection

In paragraph 6, the Examiner objected to claim 11. In response, the Applicant has amended claim 11 as suggested by the Examiner.

Prior Art Rejections

On page 6, the Examiner rejected claims 1-2, 4, and 14-15 under 35 U.S.C. 102(b) as being anticipated by Shiokawa. On page 7, the Examiner rejected claim 13 under 35 U.S.C. 103(a) as being unpatentable over Shiokawa. On page 8, the Examiner stated that claims 3, 5-12, and 18, would be allowable if rewritten to overcome the rejections under Section 112, first paragraph, and in independent form. On page 8, the Examiner also objected to claims 16-17 as being dependent upon a rejected base claim, but indicated that those claims would be allowable if rewritten in independent form. For the following reasons, the Applicant submits that all of the now-pending claims are allowable over the cited references.

Claim 1 is directed to a receiver for a received signal having two or more data levels. The receiver has two or more channel estimators and a comparator. Each channel estimator is configured to model the transmission channel to generate an estimated signal corresponding to one of the data levels. The comparator is configured to (1) receive the received signal and the estimated signal from each channel estimator and (2) select an output data level for the received signal. The Applicant submits that Shiokawa does not teach such a combination of features.

As shown in Fig. 1, Shiokawa teaches a signal processor having an adaptive equalizer 1, a maximum likelihood estimator 2, and a (1+D) demodulator 3. Maximum likelihood estimator 2 includes subtractors 30-34, squaring circuits 35-39, add-compare-select (ACS) circuit 5, and path memory 6.

In rejecting claim 1, the Examiner stated that Shiokawa discloses two or more channel estimators, citing subtractors 30-34 in Fig. 1. The Examiner also stated that Shiokawa discloses "a comparator (5) configured to receive the *signals from the channel estimators* and select and output data level for the received signal," citing column 4, lines 10-52. Significantly, in rejecting claim 1, the Examiner omitted part of the explicit recitations of claim 1.

According to claim 1, the comparator receives "<u>the received signal</u> <u>and</u> the estimated signal from each channel estimator." In rejecting claim 1, the Examiner did not state that the comparator of

Shiokawa receives the received signal. There is good reason for this omission. The fact is that ACS circuit 5 taught in Shiokawa does not receive the received signal. As such, Shiokawa does not teach the features explicitly recited in claim 1.

In paragraph 4 on page 3, the Examiner appeared to explain that he ignored the explicit recitation in claim 1 of the comparator receiving the received signal, based on his argument in the 112 rejection that the specification does not teach an example of the comparator receiving the received signal. Since, as explained earlier in response to that 112 rejection, the specification does in fact teach such an example, the Examiner's reason for ignoring the explicit recitation in claim 1 is not persuasive, and that explicit recitation must be considered by the Examiner when comparing the teachings of Shiokawa to the invention of claim 1.

However, there is no way to interpret the teachings of Shiokawa to fall within the scope of claim 1. According to Shiokawa, "each subtractor and the corresponding squaring circuit form a likelihood estimator for producing a likelihood value B." See column 4, lines 13-14. Assuming only for the sake of argument that these likelihood estimators in Shiokawa are examples of the channel estimators of claim 1, then Shiokawa fails to teach the comparator of claim 1, because ACS circuit 5 of Shiokawa does not receive the received signal; it receives only the branch metrics B from the squaring circuits. (Ironically, this argument is similar to the Examiner's own argument for rejecting claim 1 under 35 U.S.C. 112, first paragraph.)

The other possible interpretation of the teachings of Shiokawa is that Shiokawa's maximum likelihood estimator 2 is an example of a comparator that receives both the received signal (i.e., from adaptive equalizer 1) and signals corresponding to the different data levels (i.e., +1.5, +1, 0, -1, and -1.5). According to this interpretation, Shiokawa's subtractor 30-34 may be said to be analogous to subtractors 215 and 216 of Fig. 2 of the present application, and Shiokawa's ACS circuit 5 may be said to be analogous to compare-and-select circuit 217 of the present application.

Under this second interpretation, however, Shiokawa fails to teach examples of the two or more channel estimators explicitly recited in claim 1. In Shiokawa, the input to the subtractors are exact signal levels (i.e., +1.5, +1, 0, -1, and -1.5). In Shiokawa, there is no modeling of the transmission channel to generate an estimated signal corresponding to each data level (as explicitly recited in claim 1).

The Examiner cannot have it both ways. Either Shiokawa does not teach the comparator of claim 1 or Shiokawa does not teach the channel estimators of claim 1.

For all these reasons, the Applicant submits that claim 1 is allowable over Shiokawa. For similar reasons, the Applicant submits that claim 14 is allowable over Shiokawa. Since claims 2-13 and 15-20 depend variously from claims 1 and 14, it is further submitted that those claims are also allowable over Shiokawa. In view of the foregoing, the Applicant submits that the rejections of claims under Sections 102(b) and 103(a) have been overcome.

In view of the above amendments and remarks, the Applicant believes that the now-pending claims are in condition for allowance. Therefore, the Applicant believes that the entire application is now in condition for allowance, and early and favorable action is respectfully solicited.

Respectfully submitted,

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